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Original article

Effects of 3 months of full-court and half-court street basketball training on health profile in untrained men

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Abstract

Purpose: The aim of the present study was to investigate whether street basketball organized as 3 v 3 on either a half court (HC) with 1 basket or a full court (FC) with 2 baskets could improve fitness and health profiles of untrained men after 3 months of supervised training.

Methods: Thirty-five untrained men (aged 20–42 years) completed the pre- and post-intervention testing (FC: $n = 13$, HC: $n = 12$, CO (control): $n = 10$). The training attendance was 2.0 ± 0.4 and 1.9 ± 0.3 times per week in FC and HC, respectively. Mean heart rate (HR) was 83.8 ± 6.0 percent of maximal heart rate (%HR_{max}) and 84.5 ± 2.9 %HR_{max} in FC and HC, respectively.

Results: The 3 months of street basketball training on an FC with 2 baskets increased maximal oxygen uptake (2.4 mL/min/kg (95% confidence interval (CI): $1.0\text{--}3.9$)), time to exhaustion (47 s (95%CI: $26\text{--}67$)), lean body mass (0.8 kg (95%CI: $0.1\text{--}1.5$)), and bone mineral density (0.021 g/cm^2 (95%CI: $0.011\text{--}0.031$)), whereas mean arterial pressure (-5.6 mmHg (95%CI: -7.5 to 3.7)), body fat percentage (-1.6% , (95%CI: -2.5 to -0.7)), heart rate (-18 bpm (95%CI: -24 to -12)), and blood lactate (median: -1.4 mmol/L (interquartile range: -1.5 to -0.6)) during submaximal running were lowered. The changes were less pronounced after the training period when playing on an HC with 1 basket, but increases in maximal oxygen uptake (1.6 mL/min/kg (95%CI: -0.1 to 3.3)), time to exhaustion (28 s (95%CI: $9\text{--}47$)), lean body mass (1.3 kg (95%CI: $0.3\text{--}2.4$)), and lower body fat percentage (-0.9% (95%CI: -1.9 to -0.1)) were observed in this group.

Conclusion: Three months of 3 v 3 street basketball training improved fitness and led to broad-spectrum improvements in variables related to overall health profile, with the most marked effects observed when playing on an FC with 2 baskets.

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Keywords: Blood pressure; Body composition; Cardiovascular fitness; Maximal oxygen uptake; Musculoskeletal fitness; Physical demands; Small-sided games; Team sport

1. Introduction

Physical inactivity is the major cause of chronic diseases and premature death in the modern world.¹ Thus, physical activity is essential in the prevention and treatment of chronic diseases,² and participation in sporting activities is suggested as a means for improving the health of nations.³ Traditionally, endurance and strength-based activities, such as brisk walking, running, cycling, swimming, and strength training, have been

suggested for improving health profile, but in the past decade an increasing number of studies have shown that recreational team-sport activities, such as small-sided football, floorball, and handball, give broad-spectrum training stimuli that lead to improved health profiles.^{4–8} In addition, team sports are associated with positive social experiences, which may be crucial for motivating formerly inactive individuals to maintain regular physical exercise.^{9–11}

Although the beneficial adaptations following team-sport training have been established, access to suitable training facilities is often limited, especially in big cities, making team sports less applicable. Street basketball may be a suitable

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alternative, as a basketball court or a single basketball hoop can be established in most courtyards and playgrounds and are already found extensively in many cities. Furthermore, basketball may appeal to people to whom football does not appeal.

Elite and sub-elite basketball is characterized by a high number of activity changes and a wide variety of specific movements.¹² Moreover, elite and sub-elite basketball have been shown to elicit high heart rates (HRs),^{13,14} so basketball may lead to broad-spectrum health benefits similar to those observed for recreational football. However, little evidence is available relating to recreational basketball played by untrained individuals. Street basketball can be played in several ways, of which 3 v 3 on a full court (FC) with 2 baskets and on a half court (HC) with 1 basket are 2 of the most popular. However, studies have shown differences in activity profile and acute physiological response for differing game formats,^{14,15} which could possibly result in different outcomes following a training period.

The aim of the present study was therefore to investigate whether street basketball organized as 3 v 3 on either an HC with 1 basket or an FC with 2 baskets could improve fitness and health profiles in untrained men after 3 months of supervised training.

2. Methods

2.1. Participants

Fifty-two healthy untrained men aged 28.4 ± 7.0 years (range: 20–42) were included in the study. The participants had not participated in organized physical activity for the 12 months prior to the study and were nonsmokers.

After pre-testing and stratification for maximal oxygen uptake ($\text{VO}_{2\text{max}}$), the participants were randomly assigned to either 3 v 3 basketball on an FC with 2 baskets ($n = 19$; FC) or on an HC with 1 basket ($n = 19$; HC) for 3 months. In addition, an inactive control group ($n = 14$; CO) was recruited. In total, 13 participants in FC, 12 in HC, and 10 in CO completed the 3-month intervention period and post-testing and were finally included in the analysis. There were dropouts due to personal reasons, and 4 participants in the basketball groups (2 in each group) dropped out due to minor injuries (ankle sprains). All participants were fully informed about the study and possible risks before giving their written consent to participate. The study was carried out in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Copenhagen (H-1-2013-80).

2.2. Training intervention

Training was offered 3 times per week, and the participants were encouraged to participate in at least 2 sessions per week. Each training session lasted ~75 min and consisted of a short (10 min) general warm-up consisting of basic movements and various basketball drills (lay-ups, shooting, dribbling) followed by 4×12 min games interspersed with ~3 min breaks. Basketball was played as 3 v 3 (or occasionally 2 v 2) on either an HC (10×12 m) with 1 basket or an FC (20×12 m) with 2 baskets. Street basketball rules were applied. In HC, after the ball was regained from the opposition, it had to be passed to a

player behind the middle line of the FC before an attempt at scoring could be made.

The training attendance was 2.0 ± 0.4 times per week in FC and 1.9 ± 0.3 times per week in HC, with no difference between groups.

2.3. Test procedures

Pre and post the training period, all participants completed a panel of tests. No basketball training or other intense physical activities were performed 48 h prior to testing.

Cardiorespiratory fitness was determined during walking and submaximal running as well as in an incremental test until exhaustion. The treadmill test consisted of 6 min of walking at 6.5 km/h followed by a 2 min rest before 6 min of jogging at 8 km/h followed by another 2 min break before starting an incremental test until exhaustion. The incremental test started with 4 min of jogging at 8 km/h followed by 1 km/h speed inclines every minute. During the entire test, pulmonary oxygen uptake was measured by gas analyzer (OxyconPro; VIASYS Healthcare, Hoechberg, Germany) and HR was measured using Polar Team2 (Polar Team2 System; Polar Electro Oy, Kempele, Finland). Prior to walking, after each submaximal bout and at exhaustion, blood samples were collected from a catheter in the antecubital vein and analyzed for lactate using ABL 800 flex (Radiometer, Copenhagen, Denmark).

On a separate day, the participants reported to the laboratory after an overnight fast and completed a whole-body dual-energy X-ray absorptiometry (DXA) scan (LUNAR; GE Medical Systems, Madison, WI, USA). After at least 10 min of rest in the supine position in a quiet room, blood pressure was measured via the upper left arm (Omron M7; Omron Healthcare, Kyoto, Japan), 6 times separated by 1 min, and an average value was calculated. Throughout the rest period, an HR belt (Polar Team2 System) was worn to measure resting HR. After these measurements, a blood sample was taken from an antecubital vein and analyzed for fasting blood glucose, triglycerides, and cholesterol (Cobas® Liat® Rigshospitalet, Copenhagen, Denmark).

2.4. HR monitoring and time–motion characteristics

HR was recorded at 1 s intervals using short-range radio telemetry (Polar Team2 System). HR is presented relative to the individual maximal HR obtained as the highest HR measured during the incremental treadmill test to exhaustion or during training sessions. To describe training sessions, only data from the playing periods were analyzed together with accelerometer data using Catapult Sprint Version 5.1.1 (Catapult Innovations, Canberra, Australia).

The indoor mode of the GPS units (MinimaxX S4; Catapult Sports, Canberra, Australia) was used to measure player movements. A GPS unit was placed in a harness on the player's upper back as described by the manufacturer. Player load (PL) was measured by the accelerometers in the MinimaxX S4 at a 100 Hz sampling rate. PL is an estimate of physical demand combining the instantaneous rate of change in acceleration in 3 planes. PL is presented as time spent in PL zones 0–0.1,

>0.1–0.3, >0.3–0.6, >0.6–1.0, >1.0–1.5, >1.5–2.0, >2.0, and total accumulated PL. The validity and reliability of the GPS units and accelerometers have been described previously.¹⁶

2.5. Statistics

Data were tested for normality with a Shapiro-Wilk normality test. To test within-group changes, differences were analyzed using a Student's paired *t* test, whereas a one-way analysis of variance (ANOVA) was used to determine whether changes differed between groups. If data were not normally distributed, a Kruskal-Wallis test by ranks with Dunn's *post hoc* test was used.

Data describing the 2 training modes (HR, PL, etc.) were analyzed using a Student's *t* test. Effect sizes (ES) were calculated as the ratio of the mean difference to the pooled SD. All statistical analyses were performed using SigmaPlot 12 (Systat Software Inc., San Jose, CA, USA). Data are presented as means \pm SD, change scores with 95% confidence intervals (CI), and non-normal distributed data as median and interquartile range (IQR).

3. Results

3.1. Intensity during training

Mean HR during training sessions did not differ between FC and HC (83.8 ± 6.0 percentage of maximal heart rate (%HR_{max}) vs. 84.5 ± 2.9 %HR_{max}, $p=0.676$), nor did peak HR (93.5 ± 3.5 %HR_{max} vs. 94.8 ± 2.6 %HR_{max}, $p=0.256$). No differences were found between FC and HC in any of the HR zones (Fig. 1A).

Game format had a moderate effect (ES=0.65) on PL per minute and tended to be higher in FC than in HC (8.4 ± 1.4 Arbitrary Unit (AU) vs. 7.5 ± 1.0 AU, $p=0.085$). The data showed moderate effects (ES: 0.89–1.10) of game format on time spent in the highest movement intensity zones (PL zones >1.5–2.0 and >2.0), with more time spent in these categories in FC than in HC (Fig. 1B).

3.2. Effects on VO_{2max}

VO_{2max} was elevated after the training period in FC (47.1 ± 4.1 mL/min/kg vs. 44.7 ± 4.2 mL/min/kg, $p=0.006$) and tended to be elevated in HC (45.3 ± 5.3 mL/min/kg vs. 43.7 ± 5.0 mL/min/kg, $p=0.087$), but did not change in CO (43.2 ± 5.0 mL/min/kg vs. 44.6 ± 4.8 mL/min/kg, $p=0.176$). Changes were significantly different in favor of FC (2.4 mL/min/kg (95%CI: 1.0 to 3.9), $p=0.012$) and HC (1.6 mL/min/kg (95%CI: -0.1 to 3.3), $p=0.025$) compared to CO (-1.4 mL/min/kg (95%CI: -3.1 to 0.4)) (Fig. 2).

3.3. Physiological response to treadmill running

Time to exhaustion was increased after the training period in FC (621 ± 95 s vs. 574 ± 84 s, $p=0.001$) and HC (632 ± 117 s vs. 604 ± 132 s, $p=0.014$), but not in CO (534 ± 66 s vs. 555 ± 47 s, $p=0.219$), with greater changes in FC (47 s (95%CI: 26 to 67), $p=0.013$) than in CO (-6 s (95%CI: -36

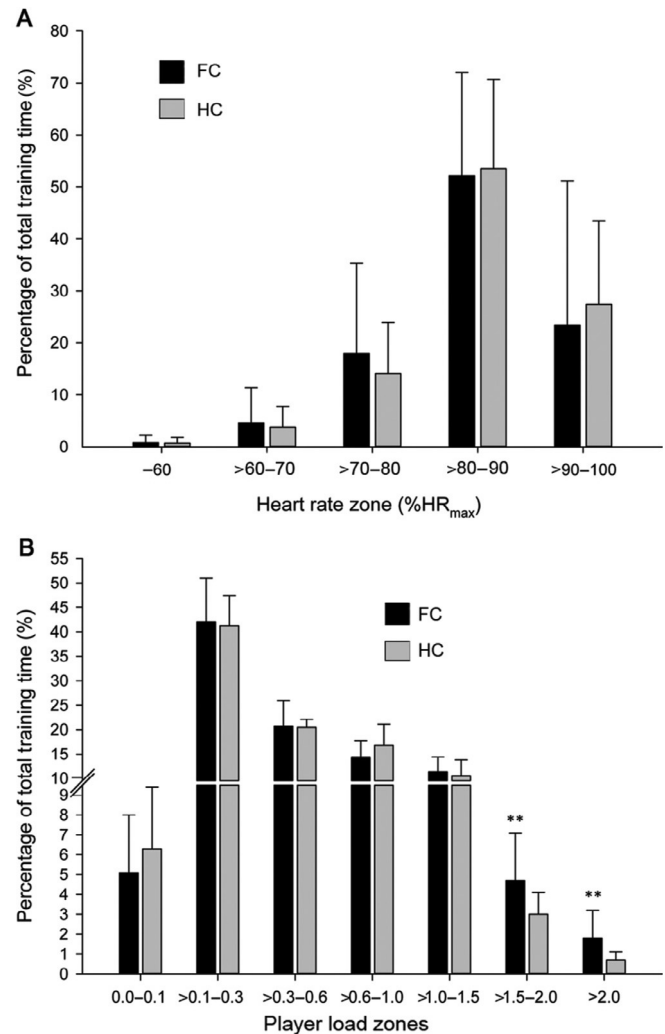


Fig. 1. Heart rate (A) and player load (B) distribution expressed as a percentage of total playing time in selected zones during basketball on a full court with 2 baskets (FC) or a half court with 1 basket (HC). Data are presented as mean \pm SD. ** $p < 0.001$, compared with HC within zone. HR = heart rate.

to 25)), whereas the change in HC tended (28 s (95%CI: 9 to 47), $p=0.057$) to be different from CO.

During submaximal running at 8 km/h, HR was lower after training in FC (143 ± 11 bpm vs. 161 ± 13 bpm, $p < 0.001$) and HC (142 ± 18 bpm vs. 152 ± 14 bpm, $p=0.014$), with no change in CO (158 ± 13 bpm vs. 163 ± 15 bpm, $p=0.218$). The change in FC (-18 bpm (95%CI: -24 to -12)) was different from CO (-5 bpm (95%CI: -12 to 2), $p=0.022$) and tended to be different from HC (-10 bpm (95%CI: -16 to -4), $p=0.099$), with no difference between HC and CO ($p=0.271$).

Blood lactate concentration after submaximal running at 8 km/h was lowered in FC (2.5 ± 1.1 mmol/L vs. 3.7 ± 1.3 mmol/L, $p < 0.001$) and HC (2.3 ± 0.9 mmol/L vs. 3.2 ± 1.4 mmol/L, $p=0.007$), but not in CO (3.7 ± 1.7 mmol/L vs. 4.1 ± 1.9 mmol/L, $p=0.481$), with greater changes in FC (-1.4 mmol/L (IQR: -1.5 to -0.6)) than in CO (-0.3 mmol/L (IQR: -0.6 to 0.45), $p=0.022$).

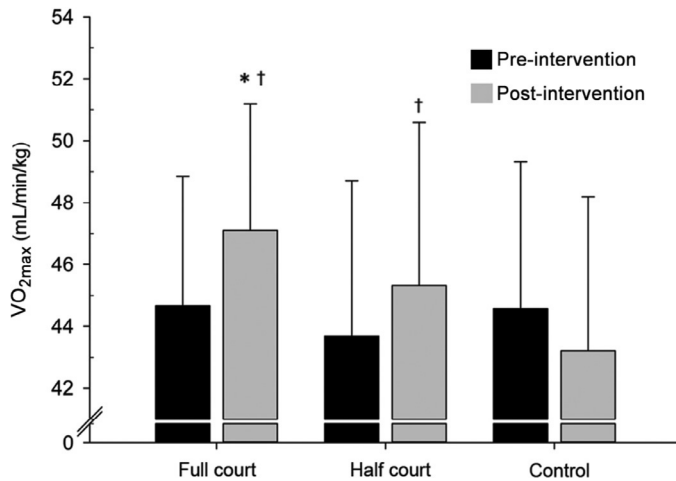


Fig. 2. Maximal oxygen uptake ($\text{VO}_{2\text{max}}$) pre and post a 3-month intervention with basketball on a half court with 1 basket, basketball on a full court with 2 baskets, or a control group continuing an inactive lifestyle. Data are presented as mean \pm SD. * $p < 0.05$, in comparison with pre-intervention within group; † $p < 0.05$, in comparison with the change in the control group.

3.4. Blood pressure and resting HR

Systolic blood pressure was lowered after the intervention period in FC (121.0 ± 7.3 mmHg vs. 124.9 ± 7.4 mmHg, $p = 0.027$), but not in HC (126.6 ± 8.0 mmHg vs. 125.3 ± 6.2 mmHg, $p = 0.519$) and CO (121.8 ± 9.7 mmHg vs. 120.9 ± 11.8 mmHg, $p = 0.506$), with the change greater in FC (-3.9 mmHg (95%CI: -7.0 to -0.9)) than in CO (0.9 mmHg (95%CI: -1.7 to 3.5), $p = 0.049$), and tended to be different from HC (1.3 mmHg (95%CI: -2.5 to 5.1), $p = 0.070$) (Fig. 3A).

Although drops in diastolic blood pressure were observed in FC (73.4 ± 5.4 mmHg vs. 79.8 ± 6.4 mmHg, $p < 0.001$) and HC (72.1 ± 5.5 mmHg vs. 77.0 ± 7.4 mmHg, $p = 0.049$), the changes in FC (-6.4 mmHg (95%CI: -8.3 to -4.6), $p = 0.125$) and HC (-4.8 mmHg (95%CI: -9.1 to -0.5), $p = 0.149$) did not differ from CO (-0.1 mmHg (95%CI: -6.6 to 6.3)) (Fig. 3B).

Mean arterial pressure was lowered in FC after the intervention period (89.3 ± 5.2 mmHg vs. 94.9 ± 6.1 mmHg, $p < 0.001$), but not in HC (90.3 ± 4.6 mmHg vs. 93.1 ± 6.3 mmHg, $p = 0.181$) and CO (91.4 ± 10.0 mmHg vs. 91.2 ± 14.2 mmHg, $p = 0.938$). The change in FC (-5.6 mmHg (95%CI: -7.5 to -3.7)) was greater than in CO (0.2 mmHg (95%CI: -4.9 to 5.3), $p = 0.022$) (Fig. 3C).

Resting HR decreased in FC when comparing post- and pre-intervention (54.1 ± 6.1 bpm vs. 58.8 ± 9.1 bpm, $p = 0.041$), but not in HC (56.4 ± 5.9 bpm vs. 58.5 ± 9.4 bpm, $p = 0.415$), and tended to increase in CO (63.3 ± 8.8 bpm vs. 59.1 ± 10.7 bpm, $p = 0.061$). However, the differences between groups were not significant ($p = 0.117$).

3.5. Body composition

Total body fat percentage decreased in FC after intervention ($23.9\% \pm 4.9\%$ vs. $25.5\% \pm 5.5\%$, $p = 0.006$) and HC ($25.3\% \pm 9.3\%$ vs. $26.3\% \pm 8.7\%$, $p = 0.049$), but increased in CO ($25.7\% \pm 7.5\%$ vs. $24.2\% \pm 7.3\%$, $p = 0.004$), with the

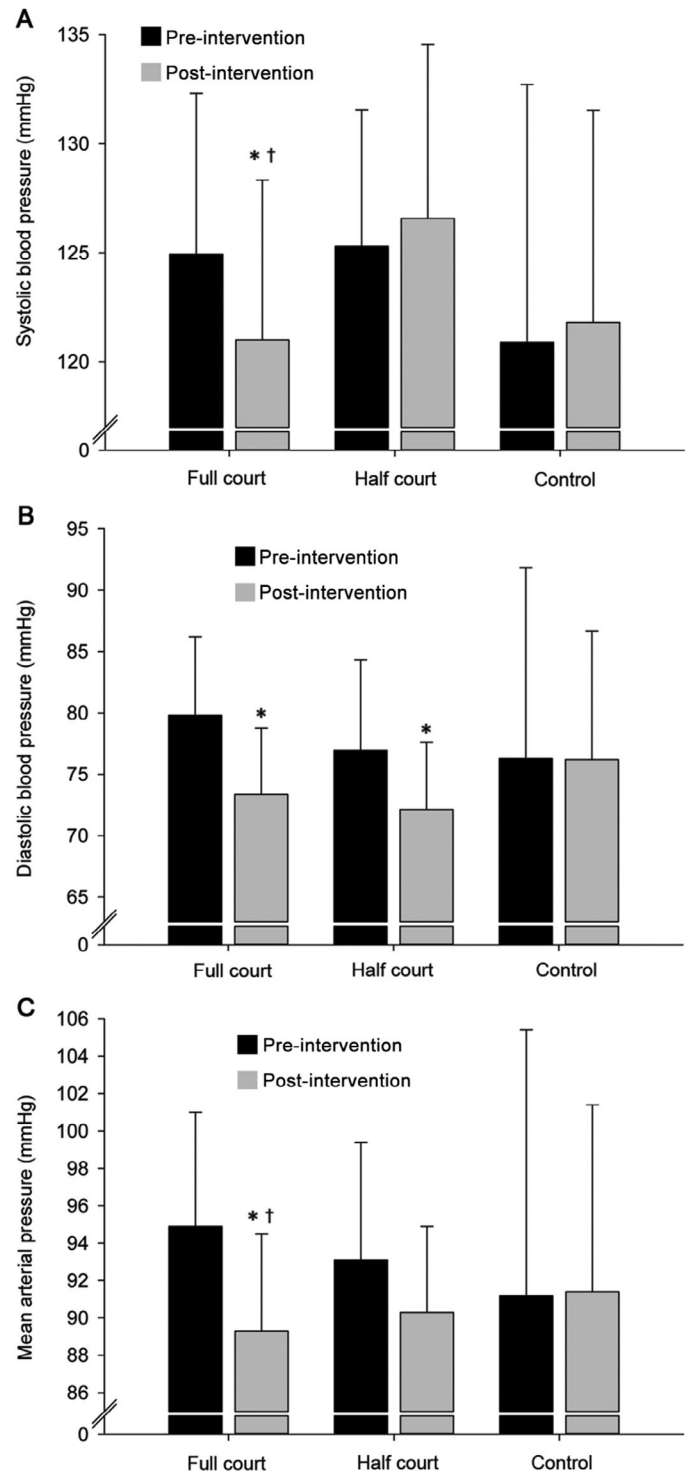


Fig. 3. (A) Systolic and (B) diastolic blood pressure as well as (C) mean arterial pressure pre and post a 3-month intervention with basketball on a half court with 1 basket, basketball on a full court with 2 baskets, or a control group continuing an inactive lifestyle. Data are presented as mean \pm SD. * $p < 0.05$, in comparison with pre-intervention within group; † $p < 0.05$, in comparison with the change in the control group.

changes in FC (-1.6% (95%CI: -2.5% to -0.7%), $p < 0.001$) and HC (-0.9% (95%CI: -1.9% to -0.1%), $p < 0.001$) different from the change in CO (1.5% (95%CI: 0.7% to 2.3%)).

Android fat percentage was lowered in FC when comparing post- and pre-intervention ($32.5\% \pm 6.3\%$ vs. $35.1\% \pm 6.8\%$,

Table 1

Fasting glucose, insulin, blood lipids, and lipoproteins pre and post a 3-month intervention with basketball on a half court with 1 basket, basketball on a full court with 2 baskets, or a control group continuing an inactive lifestyle (mean \pm SD).

	Full court			Half court			Control		
	Pre	Post	<i>p</i>	Pre	Post	<i>p</i>	Pre	Post	<i>p</i>
Blood glucose (mmol/L)	5.0 \pm 0.4	4.9 \pm 0.4	0.327	4.9 \pm 0.4	4.9 \pm 0.4	0.708	4.7 \pm 0.4	4.7 \pm 0.3	0.767
Plasma insulin (μ mol/L)	59.4 \pm 39.0	53.8 \pm 33.3	0.341	46.5 \pm 21.0	56.9 \pm 24.7	0.288	37.6 \pm 12.4	51.3 \pm 15.6	0.058
Total cholesterol (mmol/L)	4.4 \pm 1.1	3.9 \pm 1.2	0.023	4.8 \pm 0.8	4.8 \pm 0.9	0.876	4.5 \pm 1.2	4.7 \pm 1.0	0.392
HDL-C (mmol/L)	1.3 \pm 0.4	1.3 \pm 0.3	0.999	1.3 \pm 0.2	1.3 \pm 0.3	0.494	1.4 \pm 0.3	1.5 \pm 0.4	0.618
LDL-C (mmol/L)	2.6 \pm 1.0	2.4 \pm 0.8	0.146	3.2 \pm 0.7	3.1 \pm 0.8	0.554	2.8 \pm 1.2	2.8 \pm 1.1	0.941
Triglycerides (mmol/L)	1.3 \pm 1.2	1.0 \pm 0.6	0.039	0.9 \pm 0.3	0.9 \pm 0.3	0.926	0.9 \pm 0.5	1.0 \pm 0.5	0.636

Abbreviations: HDL-C = high-density lipoprotein cholesterol; LDL-C = low-density lipoprotein cholesterol.

$p=0.005$) and HC ($35.1\% \pm 11.3\%$ vs. $37.1\% \pm 10.5\%$, $p=0.007$), but elevated in CO ($34.5\% \pm 11.2\%$ vs. $32.7\% \pm 10.8\%$, $p=0.006$). The changes in FC (-2.6% (95%CI: -4.1% to -1.1%)) and HC (-2.0% (95%CI: 3.2% to 0.8%)) were different ($p < 0.001$) from the change in CO (1.8% (95%CI: 0.8% to 2.8%)).

Total body mass was unchanged in HC and FC, but increased in CO when comparing post- and pre-intervention (79.2 ± 13.8 kg vs. 78.1 ± 12.6 kg, $p=0.047$), though the changes did not differ between groups. Lean body mass was elevated after training in FC (61.1 ± 6.9 kg vs. 60.3 ± 6.9 kg, $p=0.036$) and HC (62.0 ± 4.3 kg vs. 60.7 ± 5.5 kg, $p=0.028$), with the changes in HC (1.3 kg (95%CI: 0.3 to 2.4)) different to those in CO (-0.4 kg (95%CI: -1.4 to 0.5), $p=0.032$), whereas the change in FC (0.8 kg (95%CI: 0.1 to 1.5), $p=0.068$) tended to be different from the change in CO.

3.6. Bone mineral content and bone mineral density

Bone mineral content in the legs was elevated after 3 months in FC (1402 ± 205 g vs. 1382 ± 197 g, $p=0.001$) and HC (1366 ± 209 g vs. 1350 ± 214 g, $p=0.032$), but not in CO (1224 ± 265 g vs. 1223 ± 249 g, $p=0.831$), though the changes in FC and HC did not differ from those in CO. No differences were observed in whole-body bone mineral content in either group.

Whole-body bone mineral density increased after the intervention period in FC compared with pre-intervention (1.296 ± 0.102 g/cm² vs. 1.275 ± 0.104 g/cm², $p=0.001$), but not in HC (1.286 ± 0.101 g/cm² vs. 1.282 ± 0.109 g/cm², $p=0.494$) and CO (1.232 ± 0.115 g/cm² vs. 1.227 ± 0.113 g/cm², $p=0.290$), with the change greater in FC (0.021 g/cm² (95%CI: 0.011 to 0.031)) than in CO (0.005 g/cm² (95%CI: -0.004 to 0.013), $p=0.040$), and tended to be larger than in HC (0.004 g/cm² (95%CI: -0.007 to 0.016), $p=0.063$).

3.7. Blood analysis

Total cholesterol was lowered after 3 months in FC (3.9 ± 1.2 mmol/L vs. 4.4 ± 1.1 mmol/L, $p=0.023$), but not in HC (4.8 ± 0.9 mmol/L vs. 4.8 ± 0.8 mmol/L, $p=0.876$) and CO (4.7 ± 1.0 mmol/L vs. 4.5 ± 1.2 mmol/L, $p=0.392$). However, the differences between groups were not significant ($p=0.093$).

Triglycerides were lowered after the intervention period in FC (1.0 ± 0.6 mmol/L vs. 1.3 ± 1.2 mmol/L), $p=0.039$), but

not in HC (0.9 ± 0.3 mmol/L vs. 0.9 ± 0.3 mmol/L; $p=0.926$) and CO (1.0 ± 0.5 vs. 0.9 ± 0.5 mmol/L, $p=0.636$), though the changes in FC did not differ from HC and CO ($p=0.193$). Fasting blood glucose, plasma insulin, low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C) did not change in any of the groups (Table 1).

4. Discussion

The major findings of this study were that 3 months of street basketball training played on an FC with 2 baskets improved fitness and variables related to overall health profile, with positive training effects on VO_{2max} , performance capacity, lean body mass, and bone mineral density, as well as on mean arterial pressure, body fat percentage, and physical strain during submaximal exercise. In the case of street basketball on an HC with 1 basket, the changes were less pronounced, but VO_{2max} , performance capacity, and lean body mass were elevated and body fat percentage decreased.

VO_{2max} was elevated by 2.4 mL/min/kg in FC and tended to be elevated by 1.6 mL/min/kg in HC after the 3-month training period. This training-induced change is at the lower end of what has been seen after 3-month training interventions for untrained men with other team sports, such as recreational football, recreational handball, and floorball.^{7,8,17–19} A recent meta-analysis found that the mean change after a period of recreational football training was 3.5 mL/min/kg.²⁰ Although the participants in the present study had not participated in training for at least 12 months prior to the training period, VO_{2max} was ~ 44 mL/min/kg. A large Norwegian study investigated VO_{2max} in 3816 men and women in different age groups and found mean values of 54.4 ± 8.4 , 49.1 ± 7.5 , and 47.2 ± 7.7 mL/min/kg in men aged 20–29, 30–39, and 40–49 years, respectively.²¹ Thus, the participants in the present study had values just below average. Aspenes and colleagues²² showed that men with VO_{2max} below 44.2 mL/min/kg were 8 times more likely to have a cluster of cardiovascular risk factors than those with VO_{2max} above 50.5 mL/min/kg, so the participants in the present study would benefit from increasing their cardiorespiratory fitness even though VO_{2max} was at an average level at baseline.

Another indicator of improved cardiorespiratory fitness was the lowered HR during submaximal running at 8 km/h. However, the change in HR was only significantly different from the control group in the case of the FC group. In line with this, blood lactate was lowered in both groups, but only the change

in the FC group was different from the control. This is also an indicator of improved work capacity, as less energy is derived from anaerobic energy production. Lower blood lactate and HR during submaximal work is a common finding after a period of recreational team sport.^{17,23,24} The large drop of 18 bpm in HR during submaximal running indicates an increased stroke volume. Improved structural and functional adaptations in the heart following a 12- to 26-week recreational football training program have been shown in men with mild-to-moderate hypertension and in untrained women.^{25,26} Increased stroke volume would also lead to a drop in resting HR and, in line with this, resting HR was lowered by ~5 bpm in the FC group with no change in the HC group. However, although the control group tended ($p=0.061$) to increase resting HR by ~4 bpm, no statistical difference was found between the groups. A drop of ~5 bpm is similar to the 4–6 bpm drop often reported after a recreational football training period.^{4,19,27} Resting HR has been suggested as a non-invasive independent predictor of cardiovascular diseases,^{28,29} as the risk of such diseases increases with increasing resting HR above at least 60 bpm.³⁰ The baseline values in the present study were rather low (~59 bpm), so a further drop may be of minor importance for health profile.

Mean arterial pressure was lowered after training in the FC group with no change in the HC group. This change in mean arterial pressure in the FC group was derived from a reduction in systolic blood pressure, while the HC group had a small, non-significant increase. Large drops (5–6 mmHg) in diastolic blood pressure were observed in both training groups, but the changes did not differ from the change in the control group. A number of studies have shown that team-sport activities such as recreational football and floorball effectively decrease blood pressure.^{6,17,18,27,31,32} Although the participants in the present study had normal blood pressure values at baseline, increased cardiovascular risk is evident from 115/75 mmHg,³³ so the reduction observed in the FC group can be considered relevant for the overall health profile.

Obesity is a risk factor for several chronic diseases. The participants in the present study had baseline values just above 25% body fat and can thus be considered obese, so lowering body fat would be important for an improved health profile. After the training period, body fat percentage was lowered by 0.9–1.6 percentage points, which is less than observed after small-sided football training, in which drops of 2.7–2.9 percentage points have been reported,^{6,27} but similar to continuous exercise training protocols with 2 weekly 45–60 min training sessions.³⁴ Both groups lowered their android fat percentage, which has been shown to have a stronger relationship to cardiovascular diseases than whole-body fat percentage, primarily through the association with lipoprotein profiles.^{35,36} Although android fat percentage was lowered in both groups, no changes in lipoprotein profile were observed.

In association with the decrease in fat percentage, lean body mass increased by 0.8 kg in the FC group and 1.3 kg in the HC group. It has previously been shown that recreational football training can lead to increases in lean body mass,²⁷ and lean body mass increased by 1.0 kg in homeless men after street

soccer training on a pitch comparable in size to a basketball court.¹⁹ Numerous jumps, rapid accelerations-decelerations, and turns occur often during small-sided street basketball. Similarly, specific actions observed during recreational football have been associated with muscular adaptations, including hypertrophy.⁴ The many specific actions with a high number of intense impacts on the legs have also been associated with changes in bone mineralization.^{37,38} In agreement with these studies, an increase in bone mineral density was observed in the FC group. This increase was higher than in the control and tended to be higher than in the HC group.

Overall, changes were more evident in the FC group than in the HC group. Although mean HR and time spent with high HR did not differ between the 2 training groups, minor differences were found in the activity profile, with PL per minute tending to be higher in the FC group and more time spent in the high PL zones. This agrees with studies on elite junior players that found similar HR responses but differences in activity profiles between HC and FC basketball.¹⁵ An explanation for the similar HR response but markedly different activity profiles may be a higher amount of static work during HC basketball, which could cause increased HR without concurrent movement.

5. Conclusion

Three months of street basketball played on an FC with 2 baskets led to broad-spectrum of improvements in health profiles, with increases in $\text{VO}_{2\text{max}}$, performance capacity, lean body mass, and bone mineral density and decreases in mean arterial pressure, body fat percentage, HR, and blood lactate during submaximal running. Changes were less pronounced after the training period in the case of an HC with 1 basket, but increases in $\text{VO}_{2\text{max}}$, performance capacity and lean body mass and a decrease in body fat percentage were observed in this group.

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Authors' contributions

MBR conceived of the study design, applied for funding, carried out the data collection and analysis, interpreted the study results, and drafted the manuscript; MH and JB participated in training, data collection and analysis, and edited the manuscript; JFC, MTP, and JJN carried out data collection and edited the manuscript; PK conceived of the study design, applied for funding, interpreted the study results, and edited the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

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